Mixed fisheries forecasts in the Atlantic Iberian waters: preliminary results

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INTRODUCTION

During the last WGHMM meeting, it was revised the applicability of a mixed-fisheries approach to the species assessed by this WG (WD6, Castro and Santurtun, 2012). Due to the lack of accepted assessment for most of the Northern stocks (Iriondo *et al*., 2012), it was found more advisable to focus efforts on the Southern stocks, i.e. those distributed by Iberian waters (ICES Divisions VIIIc and IXa). Subsequently, this task was adopted as ToR by WGMIXFISH in order to compile the required data for the provisional Fcube application in Iberian waters.

The first mixed-fisheries analysis conducted on the WGHMM Southern stocks was performed by the STECF using the MTAC method in 2004 (STECF, 2004). Later, a mixed-fisheries approach conducted by ICES on Iberian stocks allowed identifying an inconsistency within the first Fcube version, time from which the biomass parameter was included in the Fcube algorithm (ICES, 2006). This new version was tested with Iberian fishing data using an updated, but pre-DCF, fleet disaggregation (IBERMIX, 2007) on four fish stocks and three Functional Units of Norway lobster at ICES SGMIXMAN (ICES, 2007).

Unfortunately, after six years is still necessary to coordinate an extra effort between the national laboratories in order to address a new mixed-fisheries analysis on Iberian stocks, especially with regard to data compilation. Currently, fishery WGHMM data are not usually provided to ICES through InterCatch, and sometimes they present different fleet disaggregation by stock in the report. Therefore, IEO (Spain) and IPMA (Portugal) took the opportunity of the GEPETO project (Atlantic Area, 2011/1-159) to develop the Iberian mixed-fisheries case study.

Besides the Iberian demersal stocks assessed by WGHMM, i.e. five stocks of demersal fish (Southern stocks of hake, megrim, 4-spot megrim, white and black anglerfish) and 7 Functional Units of Norway lobster (FU25 to FU31), some pelagic stocks also occur in the landings of some traditional demersal fisheries. This has always been so in the case of some metiers, but others have evolved in order to also exploit pelagic species as mackerel, horse mackerel, and blue whiting. In fact, these pelagic species are economically critical in some of these demersal fisheries; as it has been pointed by the fishery industry, which also participates in the GEPETO project.

Therefore, the first goal of the present WD is to compile the fishery data for the most important stocks exploited in the Atlantic Iberian waters, regardless their ecological group, disaggregated by the current DCF fishery units, i.e. métier and fleet segment. Once done, the next step is to carry out mixed-fisheries analyses in order to provide preliminary mixed-fisheries forecasts for Iberian waters.

MATERIAL AND METHODS

Data

Fleet and metier specific catch (landings and discards) and effort data were compiled for the "Iberian waters" case study developed by GEPETO project, taking Spanish and Portuguese official statistics (sales notes and logbooks) for the last three-year period (2010-2012). These matrices were disaggregated into DCF métier and fleet segment by the respective national laboratories (IEO and IPMA) and, then, landings of each stock were raised to the scientific estimates used by the respective ICES assessment WGs.

Due to the inclusion of an "unallocated" column in the landings table for the last two years, the allocation found in the official data sources (between stocks and metiers) was weighted to the scientific estimates provided to ICES. In this way, the consistency between the year 2010 and the period 2011-2012 could be maintained. Regarding effort, two types of units were compiled: days of fishing and KW*fishing days. Given the lack of differences in the results of preliminary analyses with both effort units, it was decided to use kw*fd in the final runs.

Therefore, both categories defined by the CEC's Data Collection Framework (DCF, Reg. (EC) Nº 949/2008 and Commission Decision 2010/93/UE) were adopted:

- **Métier**: from the current 24 Spanish métiers in Iberian waters, 11 métiers were selected due to present catches of the target species in the analysis[1] (Table 1a). The Portuguese fishing activity was disaggregated into 4 métiers (Table 1b).
- **Fleet segment**: group of vessels with the same length class and predominant fishing gear during the year. The selected metiers are fishing activities developed by vessels from 24 fleet segments (Table 2).

The number of stocks considered in the analyses had to be finally reduced to five (Table 3), only those with analytical assessment accepted by ICES this year: hake (HKE), southern horse mackerel (HOM9), four-spot megrim (LDB), megrim (MEG), and white anglerfish (MON). The following biological parameters were taken from the assessments developed by the respective ICES WGs (ICES, 2013a; ICES, 2013b): abundance [N], mean weight [w], fishing [F] and natural mortality [M][2] by age. The southern stock of black anglerfish is assessed by ASPIC, method which provides relative biological parameters (F/F_{MSY} and B/B_{MSY}) of difficult employment in a mixed fishery analysis. All the Functional Units of Norway lobster in Iberian waters are currently assessed by qualitative methods. The other pelagic stocks also exploited by Iberian demersal fisheries (mackerel, blue whiting and western stock of horse mackerel) will be assessed at ICES WGWIDE while the WGMIXFISH_METH meeting.

All the selected stocks are assessed by using landings; except for the HKE assessment where catches (landings and discards) are used.

[1] Metiers rejected: 13 metiers directed to clams, cephalopods or fish stocks not included in the analysis.
[2] Special outputs: HKE and MON are currently assessed by using length-based methods. Their age-based outputs were provided by the respective stock coordinators.

Methodology

The methodology applied was the Fcube model (Ulrich *et al*., 2011), and the approach follows that used for the North Sea mixed fisheries advice (ICES, 2013c): the Status Quo effort assumption has been used for the intermediate year (2013), and the Fcube scenarios used for the TAC year (2014). The following five scenarios were considered:

1. **MAX**: The underlying assumption was that fishing stops when all quota species are fully utilised with respect to the upper limit corresponding to single stock exploitation boundary.
2. **MIN**: fishing stops when the catch for the first quota species meets the upper limit corresponding to single stock exploitation boundary.
3. **HKE**: all fleets set their effort at the level corresponding to their hake quota share, regardless of other stocks.
4. **ESQ**: effort was set as equal to the most recently recorded year for which there are landings and discard data (2012).
5. **EMR**: effort was adjusted according to the current effort management regime[3] implemented in Atlantic Iberian waters in relation with the management plan for the recovery of Southern hake and Iberian Norway lobster stocks[4].

For the last scenario, due to the lack of official data (number of affected vessels by métier)[5], it was parameterized by applying the threshold in force to the observed data: vessels bigger than 10 m using trawl gears (>32 mm), gill nets (> 60 mm) or long lines with landings of hake annually higher than 5 t (except for vessels operating in the Gulf of Cadiz).

The WGHMM single-stock forecasts were reproduced in order to evaluate the potential difficulties to gather all forecasts into a single unified framework (baseline run). Besides, two management constraints were also taking into account to check if they are kept in the results: the UE Relative Stability Principle and the Spanish catch allocation by fleet group and stock.

[3] Regulation CE Nº 27/2005, 51/2006, 41/2007, 40/2008, 43/2009, 23/2010, 57/2011, 44/2012 and 39/2013.
[4] "*Measures for the recovery of Southern hake and Norway lobster stocks in Cantabrian Sea and Western Iberian*" (Regulation CE Nº 2166/2005).
[5] No Spanish data for years 2010 and 2011 in STECF (2013), where effort is provided sorted by gear and special condition (SPECON).

RESULTS

Fcube analyses of the TAC year (2014)

In the intermediate year (2013), the reproduced single-stock forecasts gave similar results in all stocks except for HKE (-9.4%) and MON (-8.0%). It must be noted that HKE and MON are assessed by using length-based methods, GADGET and SS3 respectively. However, the discrepancies are higher in 2014, -10.9% and -14.3% respectively, but also in the case of MEG (-19.9%) (Table 4). This is the smallest stock in catches (0.6% of total catches) and any small variation in the allocation of fishing opportunities among stocks may have a major impact on this stock.

Results of running Fcube scenarios for 2014 are given in Table 5 and Figures 1 and 2. Scenario MAX provides the highest over-quota for HKE (around 100%). Scenarios MIN, and HKE forecast similar losses by stock, identifying HKE as the limiting stock. Scenario ESQ seems to be in line with the HOM9 and MON TACs. However, scenario EMR provides catch losses for most of stocks except HKE, whose over-quota achieves around 20%.

Scenario MAX provides increases of effort for all metiers, around 50% for trawlers and higher than 100% for passive gears (Figure 2). Scenarios MIN, HKE and ESQ reduce similarly the effort for all metiers (around 25%), except for purse seine (PSX_SPF_0_0_0) which is increased 80% and 60%, respectively. However, metier GN_DEF_>100_0_0 targeting MON ("*rasco*") is also increased in scenario HKE, revealing that HKE does not occur in its catches. Scenario EMR allocates the initial 10% effort reduction to metiers targeting hake, as "*volanta*" gillnets or bottom trawlers directed to demersal fish, and just let an increase of effort to OTB_MCD>=55_0_0, metier exempted of effort control.

Table 6 show the ratios of landings (forecasted/observed) by fleet-segment group (all length classes of the same predominant gear) and Fcube scenario. The following losses in catch possibilities are obtained: gillnet and longline in scenarios MAX (0.85) and EMR (0.95), trawl in all scenarios (from 0.60 to 0.93) except scenario MAX, polyvalent segment in scenarios MIN (0.85) and EMR (0.93), and purse seiner in all scenarios (from 0.86 to 0.98).

European and National regulations

The Relative Stability Principle is generally respected (discrepancies <2%), except for HOM9 in scenarios MIN and HKE with increases of 17% for Spain.

The Spanish government has recently established an allocation system of the national quotas by fleet category[6] ("*modalidad*"): lineal by vessels for trawl, and calculated combining historical landings and number of fishers for artisanal categories. Obviously, the Fcube results give the same allocation regardless the scenario, because the input allocation is lineally reproduced. Except for megrims, which are only catch by trawl, the remained species show discrepancies regarding the regulated allocation (Figure 5). The common point is an observed infra-utilization of trawl sub-quota by trawl (20% for HKE, 50% for HOM9 and 40% for MON), which may be derived from the fishers' declarations in logbooks.

6 Order AAA/1307/2013, 1 July 2013, Management plan for vessels registered into the national fishing ground of Cantabrian and North-western.

DISCUSSION

Application of the Fcube approach to Iberian waters is sufficiently developed to be implemented in the **ICES mixed-fisheries advice process**. The scenarios here explored seem to properly reflect the implications of single-stock advice in a mixed-fishery context.

In this sense, the **Fcube method** may be particularly useful. On the one hand, it allows analyzing and understanding the technical interaction between stocks and fleet units. On the other, this rationalization of the fishery system can be employed in the management both in Europe (determination of TAC) and at national level (quota allocation). Perhaps the most critical aspect of the Fcube method is that it does not include information on how each fishery unit affects the population structure of each stock. Thereby fleet units are "rewarded" or "penalized" in terms of the biomass caught regardless of the amount of juvenile or spawners. Another aspect that is often criticized in this type of mixed-fisheries analysis is the difficulties encountered in the data collection. It is true that the feeding of the model requires a high level of disaggregation, but after four years of the DCF implementation, information with the required quality already exists and, generally, most limitations on the extent of its use comes from the inertia of some scientific forums.

In the longer term, it would be desirable to develop a single **management plan** for all species in the Iberian mixed fisheries. The management plan currently in force is focused on hake and Norway lobster, although progress has been made in the inclusion of anglerfishes (STECF, 2011). In 2011, DGMARE launched a public consultation in order to revise the management plan (DGMARE, 2011). The replies from the industry can be organized around a number of key points: revision of the current closures, to test different effort regimes for active and passive gears, or to optimize effort by reducing the fleet capacity. An important criticism of the current management plan is the lack of link between input and output management measures: since its implementation (2005), the TAC of hake has been increased around 12% per year, while effort has been reduced around 8%.

Regarding the **data collection**, this could be facilitated greatly if the ICES assessment groups applied the DCF structure to provide fisheries data. In this sense, the ICES database InterCatch is the best source from which to provide appropriate data to different ICES expert groups.

The **baseline runs** try to reproduce the single species advice produced by ACOM, because it is necessary to gather all single-stock forecasts into a single unified mixed-fisheries framework. The same forecast settings as in WGHMM and WGHANSA are used for each stock regarding weight-at-age, selectivity and recruitment, as well as assumptions on the F in the intermediate year and basis for advice (MSY or MSY approach). However, high discrepancies have been found on stocks assessed by length-based models, as HKE (GADGET) and MON (SS3). Age-based parameters of these stocks were specifically provided for this mixed-fisheries analysis, and they are inferred from their length-based outputs by applying the respective von Bertalanffy growth equations. These GADGET and SS3 applications use length-based forward projection models through optimisation algorithms.

As a cross check, the landings by national fleets were summed over nation for each scenario, and the share by country was compared with this initial input. The results show only minor deviations from the **Relative Stability** across all scenarios, except for HOM9 in scenarios MIN and HKE. This may have relation with the mono-specificity of purse seine fleet segment. This situation might change after including other target stocks of this fleet, as mackerel (MAC) and the western stock of horse mackerel (HOM8). With the aim to extend the approach, the inclusion of blue whiting (WHB) could be also considered.

CONCLUSIONS

- Mixed-fisheries approach ready to be applied on Iberian waters within the ICES mixed-fisheries advice process.
- Discrepancies with forecasts from stochastic length-based assessment models should be studied in detail in the future.
- The ICES assessment groups should make an effort to integrate their data structure taking advantage of existing tools that can simplify this (InterCatch).
- The introduction of pelagic stocks is appropriate in Iberian mixed-fisheries forecasts, therefore other pelagic stocks without assessment at this time of year should be considered in future analyses.

References

Castro J. and M. Santurtun. 2012. Mixed-fisheries advice for ICES WGHMM stocks. WD6 presented at ICES WGHMM 2012. 10-16 May 2012, ICES Headquarters, Copenhagen [ICES CM 2012/ACOM: 11].

DGMARE. 2011. http://ec.europa.eu/fisheries/partners/consultations/hake/index_en.htm

IBERMIX. 2007. Identification and segmentation of mixed-species fisheries operating in the Atlantic Iberian Peninsula waters (IBERMIX project): Final Report to European Commission Director-General Fisheries. DGFISH/2004/03-33.

ICES. 2006. Report of the Working Group on the Assessment of Southern Stocks of Hake Monk and Megrim (WGHMM). ICES CM 2006/ACFM:29, 792 pp.

ICES. 2007. Report of the Study Group on Simple Mixed Fisheries Management Models (SGMIXMAN). ICES CM 2007/ACFM:02, 52 pp.

ICES. 2013a. Report of the Working Group on the Assessment of Southern Shelf Stocks of Hake, Monk and Megrim (WGHMM), 10-16 May 2013, ICES Headquarters, Copenhagen. ICES CM 2013/ACOM: 11A. 719 pp.

ICES. 2013b. Report of the Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA).

ICES. 2013c. Report of the Working Group on Mixed Fisheries Advice for the North Sea (WGMIXFISH-NS), 20-24 May 2013, ICES Headquarters, Copenhagen. ICES CM 2013/ACOM: 22. 115 pp.

Iriondo, A., García, D., Santurtún, M., Castro, J., Quincoces, I., Lehuta, S., Mahévac, S., Marchal, P., Tidde, A. and C. Ulrich. Managing mixed fisheries in the European Western Waters: Application of Fcube methodology. Fisheries Research, 134– 136: 6– 16.

STECF. 2004. Report of the Subgroup on Resource Status (SGRST) of the Scientific, Technical and Economic Committee for Fisheries (STECF) on Mixed Fisheries. SEC(2004) 1711: 95 pp.

STECF, 2011. Impact Assessment of multi-annual plans for Southern hake, anglerfish and Nephrops (STECF-11-06).

STECF. 2013. Evaluation of Fishing Effort Regimes in European Waters - Part 1. (STECF-13-06). Publications Office of the European Union, Luxembourg.

Ulrich, C., Reeves, S. A., Vermard, Y., Holmes, S. J., and Vanhee, W. 2011. Reconciling single-species TACs in the North Sea demersal fisheries using the Fcube mixed-fisheries advice framework. *ICES Journal of Marine Science*, 68: 1535–1547.

Table 1. List of the Spanish DCF metiers of Atlantic Iberian waters (ICES Divisions VIIIc and IXa) used in the analyses carried out. Data source: logbooks, sales notes and fleet census of 2010-2012.

Acronym	Definition	Description	Nº of Vessels	Mean LOA
GNS_DEF_>=100_0_0	Set gillnet targeting demersal fish with mesh sizes larger than 100 mm	Set gillnet called "*rasco*" targeting anglerfishes (mainly white anglerfish) in ICES Div. VIIIc with mesh size of 280 mm	25	17.4
GNS_DEF_60-79_0_0	Set gillnet targeting demersal fish with mesh sizes within the range 60-80 mm	Small set gillnet targeting to a variety of demersal fish in north-western Spanish waters	331	11.0
GNS_DEF_80-99_0_0	Set gillnet targeting demersal fish with mesh sizes within the range 80-100 mm	Set gillnet called "*volanta*" targeting hake with nets of 90 mm mesh size in north-western Spanish waters	57	17.4
GTR_DEF_60-79_0_0	Trammel net targeting demersal fish with mesh sizes within the range 60-80 mm	Trammel net targeting a variety of demersal species in north-western Spanish waters	843	8.8
LHM_DEF_0_0_0	Hand line targeting demersal fish	Hand line targeting hake in ICES Division VIIIc (spring)	13	12.6
LLS_DEF_0_0_0	Set longline targeting demersal fish	Set longline targeting a variety of demersal fish in Spanish Iberian waters	540	12.1
OTB_DEF_>=55_0_0	Bottom otter trawl targeting demersal fish using mesh sizes larger than 55 mm	Bottom otter trawl targeting hake, anglerfish and megrim using "*baca*" nets of 70 mm mesh size in north-western Iberian waters (both Spanish and Portuguese waters north of Peniche)	66	28.1
OTB_ MCD_>=55_0_0	Bottom otter trawl targeting mixed crustaceans and demersal fish using mesh sizes larger than 55 mm	Bottom otter trawl targeting crustaceans (rose shrimp and Norway lobster) and fish (hake…) using nets of 55 mm mesh size in south-western Iberian waters (both Spanish and Portuguese waters south of Peniche)	149	19.2
OTB_MPD_>=55_0_0	Bottom otter trawl targeting mixed pelagic and demersal fish using mesh sizes larger than 55 mm	Bottom otter trawl targeting pelagic (horse mackerel, mackerel…) and demersal fish (hake) by using "*jurelera*" nets of 55 mm mesh size in north-western Spanish waters	57	29.2
PS_SPF_0_0_0	Purse seine targeting small pelagic fish	Purse seine targeting mackerel, horse mackerel, sardine and anchovy in successive seasonal fisheries in Iberian waters	437	17.9
PTB_ MPD _>=55_0_0	Bottom pair trawl targeting mixed pelagic and demersal fish using mesh sizes larger than 55 mm	Bottom pair trawl targeting pelagic (blue whiting, mackerel…) and demersal fish (hake) by using nets of 55-70 mm mesh size in north-western Spanish waters	46	27.9

Table 1b. List of Portuguese DCF metiers of Iberian waters (ICES Division IXa) used in the analyses carried out.

Acronym	DCF definition	Description	Nº of Vessels	Mean LOA
MIX_polyvalent	-----	Only the fraction of the polyvalent fleet with catches from stocks included in the analysis was considered	1316	5.5
OTB_CRU_>=55_0_0	Bottom otter trawl targeting crustaceans using mesh sizes larger than 55 mm	Bottom otter trawl using nets of 55 mm mesh size to catch rose shrimp and 70 mm to catch Norway lobster	25	28.4
OTB_DEF_>=55_0_0	Bottom otter trawl targeting demersal fish using mesh sizes larger than 55 mm	Bottom otter trawl targeting horse mackerel, hake, anglerfish and megrim using nets of 65 mm mesh	54	24.0
PS_SPF_0_0_0	Purse seine targeting small pelagic fish	Purse seine targeting sardine, chub mackerel, bogue, anchovy and horse mackerel	105	19.1

Table 2. List of fleet segments used in the analysis.

Acronym	VL0010	VL1012	VL1218	VL1824	VL2440	VL40XX
DFN	DFN0010	DFN1012	DFN1218	DFN1824	DFN2440	--
DTS	DTS0010	--	DTS1218	DTS1824	DTS2440	--
HOK	HOK0010	HOK1012	HOK1218	HOK1824	HOK2440	--
PGP	PGP0010	PGP1012	PGP1218	PGP1824	PGP2440	--
PSX	PSX0010	PSX1012	PSX1218	PSX1824	PSX2440	--

GEARS:

- **DFN**: drift and/or fixed netters
- **DTS**: demersal trawlers and/or demersal seiners
- **HOK**: vessels using hooks
- **PGP**: polyvalent artisanal fleet
- **PSX**: purse seiners

LOA (overall length):

- **VL0010**: vessel between 0 meters and 10 meters in length.
- **VL1012**: vessel between 10 meters and 12 meters in length.
- **VL1218**: vessel between 10 meters and 18 meters in length.
- **VL1824**: vessel between 18 meters and 24 meters in length.
- **VL2440**: vessel between 24 meters and 40 meters in length.
- **VL40XX**: vessel greater than 40 meters in length.

Table 3. List of potential stocks to be considered in an Iberian mixed-fisheries analysis.

Code	Common name	Scientific name	Stock	Analytical assessment	2014 ICES Advice (t)	Approach
ANK	Black anglerfish	*Lophius budegassa*	VIIIc-IXa	ASPIC	1153	MSY
HKE	Hake	*Merluccius merluccius*	VIIIc-IXa	GADGET	13123	Transitional
HOM	Horse mackerel	*Trachurus trachurus*	VI-VIII	ADAPT-VPA	---	---
			IXa	AMISH	35000	MSY
LDB	Four-spot megrim	*Lepidorhombus boscii*	VIIIc-IXa	XSA	1957	MSY
MAC	Mackerel	*Scomber scombrus*	I-IX	ICA	---	---
MEG	Megrim	*L. whiffiagonis*	VIIIc-IXa	XSA	300	MSY
MON	White anglerfish	*Lophius piscatorius*	VIIIc-IXa	SS3	1476	MSY
NEP	Norway lobster	*Nephrops norvegicus*	FU25	NO	0	PA
			FU2627	NO	0	PA
			FU2829	NO	110	DLS
			FU30	NO	90	DLS
			FU31	NO	0	PA
WHB	Blue whiting	*Micromesistius poutassou*	I-IX	SAM	---	---

Table 4. Comparison between baseline run and ICES advice for finfish in the TAC year (2014).

Year		HKE	HOM9	LDB	MEG	MON
2013	landings	17951	24452	1807	236	1232
	ICES	19640	24000	1807	236	1330
	% difference	-9.4	1.8	0.0	-0.1	-8.0
2014	landings	11834	36772	1911	250	1291
	ICES	13123	35000	1957	300	1476
	% difference	-10.9	4.8	-2.4	-19.9	-14.3

Table 5. Results of landings by stock and Fcube scenario for the intermediate year (2013) and the forecast year (2014).

Stock	Advice 2014	MAX	MIN	HKE	ESQ	EMR
HKE	13123	27757	11063	11063	11116	17524
HOM9	35000	30877	23034	23096	31143	19641
LDB	1957	1476	562	562	1048	869
MEG	300	277	106	106	197	163
MON	1476	2010	773	930	1410	1260

Table 6. Ratios of landings (forecasted/observed) by fleet-segment group (all length classes of the same predominant gear) and Fcube scenario for both the intermediate year (2013) and the TAC year (2014).

Scenario	Gillnet	Trawl	Long line	Polyvalent	Purse seine
MAX	0.85	1.16	0.85	1.47	0.86
MIN	1.05	0.60	1.08	0.73	0.98
HKE	1.15	0.93	1.18	1.12	0.98
ESQ	1.14	0.93	1.18	1.06	0.98
EMR	0.95	0.72	0.93	0.93	0.93

Figure 1. Plot of ratios of landings (landings expected regarding the ICES advice for 2014) by stock and Fcube scenario.

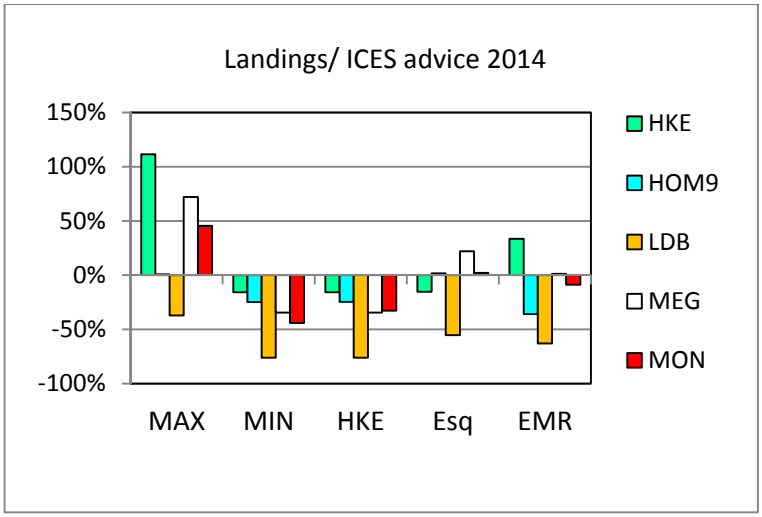

Figure 2. Plot of ratios of effort (effort expected/effort oberved) by metier and Fcube scenario.

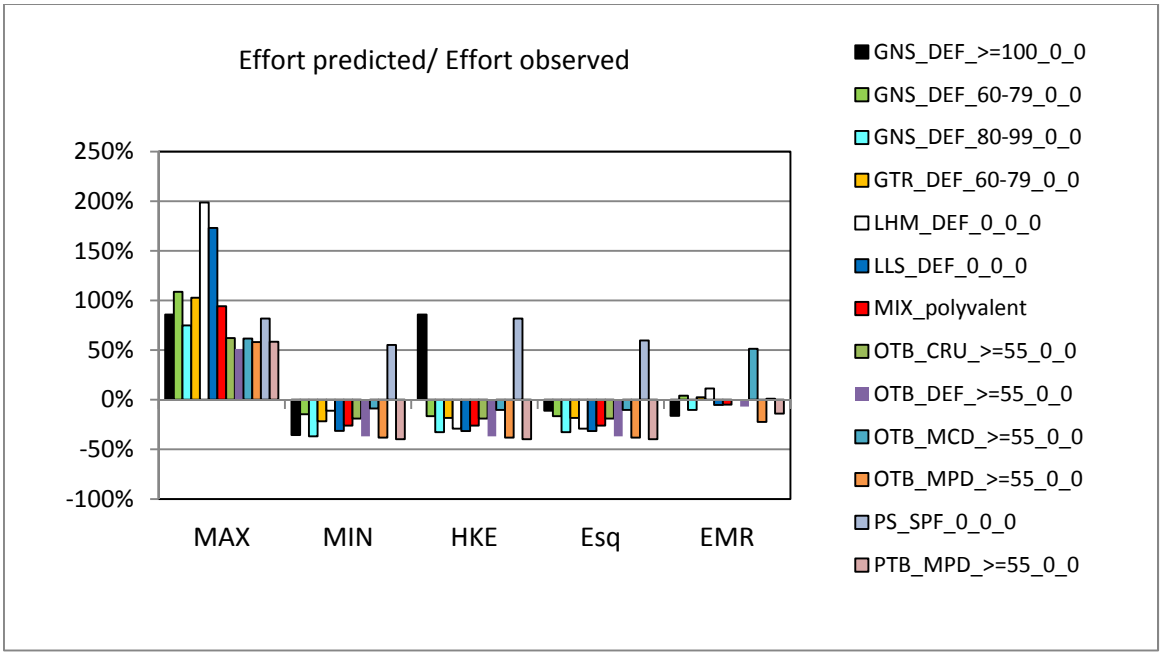

Figure 3. Comparison between the predicted Spanish landings and the official allocation by fleet category.